

## Review of methodologies used to derive numeric James River chlorophyll *a* criteria

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## Basis of Current Chlorophyll *a* Criteria

From Al Pollock's August 2011 presentation to James River Chl *a* Criteria SAP

- 1) Unbalanced phytoplankton community composition (PIBI, diversity)
- 2) Undesirable or nuisance aquatic plant life (HABs), food quality issues
- 3) Natural characteristics
- 4) Attainability

### Questions to address today

- Are there new approaches or additional information? ///
- Could they support or change existing criteria? ///
- Should previously used method(s) be revisited? ///

2

## 1) "Unbalanced" phytoplankton community

- Index of Biotic Integrity (IBI)
- Risk of algal blooms
- Diversity metrics
- Growth rate

3

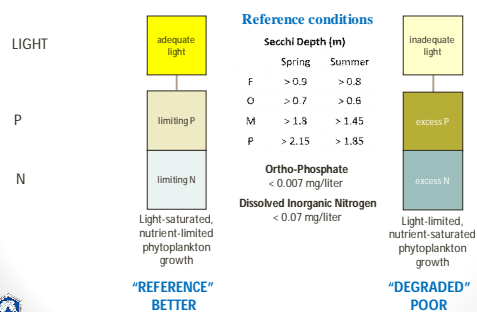
## Reference-based approach

- An widely-recognized method frequently used to characterize "balanced," "least-impaired," "stable" communities
- Increasing divergence from Reference values signals impairment
- Reference can be historical data
  - Sporadic 1950s – 1960s records of Chl *a* characterize a more balanced, mesotrophic ecosystem (USEPA 2003)
  - Should the 1960s be a reference period?
  - Historical data provide perspective but are questionable as an endpoint
- Reference can be existing communities in habitat conditions that meet specific, desired levels

4

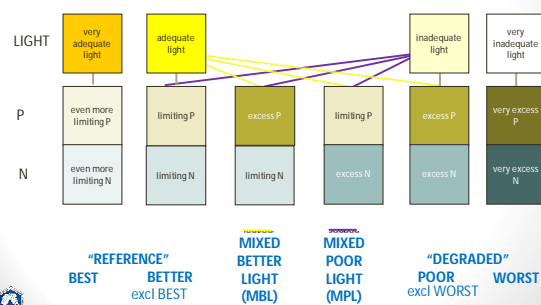
## Reference-based approach

Reference conditions found when approach applied to 1984-2002 tidal data



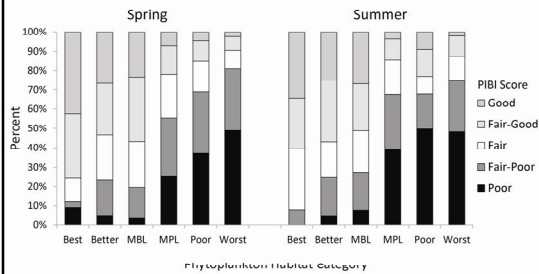
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## Reference-based approach



6

## Phytoplankton IBI 1985 – 2010

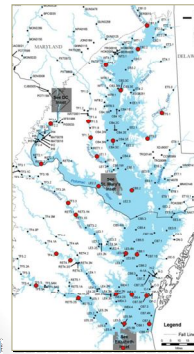


Additional information /// supports "balanced community" basis for Chla criteria /// index's responsiveness to water quality was confirmed recently

From Johnson & Buchanan (2013)

[ 7 ]

## Chlorophyll in additional reference samples



Number of reference samples at:  
Phytoplankton stations (1985 – 2010) • n = 714  
Water quality stations (1984 – 2007) • n = 3,456

[ 8 ]

## Chlorophyll in additional reference samples

### SPRING

Chla (ug/liter)	median	mean	90%ile	95%ile	n	Orig. 95%ile <sup>1</sup>	n	Scoring most like Ref <sup>2</sup>	Passing <sup>2</sup>	James R Chla Crit.
Tidal Fresh*	3.0	4.3	<b>10.8</b>	15.7	364	13.5*	21	4.4 – 14.0	3.4 – 14.5	<b>10/15</b>
Oligohaline*	9.9	11.9	<b>21.6</b>	28.2	285	24.6*	40	8.8 – 20.9	6.8 – 33.6	<b>15</b>
Mesohaline	6.0	9.0	<b>17.1</b>	26.8	142	23.8*	139	2.9 – 6.2	2.6 – 8.0	<b>12</b>
Polyhaline	3.1	3.5	<b>6.4</b>	7.3	161	6.4	58	≤ 2.8	≤ 4.0	<b>12</b>

### SUMMER

Chla (ug/liter)	median	mean	90%ile	95%ile	n	Orig. 95%ile <sup>1</sup>	n	Scoring most like Ref <sup>2</sup>	Passing <sup>2</sup>	James R Chla Crit.
Tidal Fresh*	7.8	11.1	<b>24.4</b>	31.9	652	15.9*	64	5.4 – 12.0	≤ 12.3	<b>15/23</b>
Oligohaline*	7.9	10.9	<b>22.1</b>	28.4	545	24.4*	86	4.2 – 9.5	≤ 9.5	<b>22</b>
Mesohaline	7.6	8.4	<b>12.7</b>	15.3	1061	13.5	128	4.0 – 7.7	≤ 9.7	<b>10</b>
Polyhaline	4.7	4.9	<b>7.8</b>	9.0	246	9.2	56	≤ 4.5	≤ 5.3	<b>10</b>

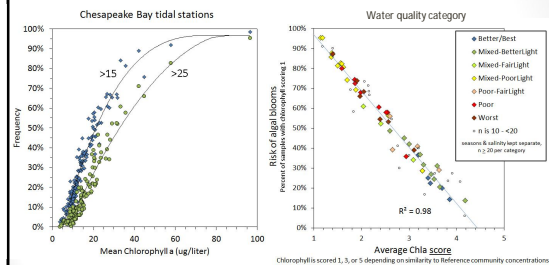
<sup>1</sup> Buchanan et al. 2005 <sup>2</sup> Lacouture et al. 2006 \* includes MBL as Reference \* scores 5 on scale of 1-5-5

Additional information /// corroborates James Chla criteria: indicates reference conditions are amply present and thus attainable /// update?

[ 9 ]

## Risk of algal blooms

- Risk is tightly related to the mean value or score of Chla



Additional information /// supports "balanced community" basis for Chla criteria /// empirical relationships could be used to verify simulated Chla responses to TMDL-imposed nutrient and sediment reductions

[ 10 ]

## PIBI-related publications

- Phytoplankton Reference Communities for Chesapeake Bay and its Tidal Tributaries. Buchanan et al. 2005. Estuaries 28(1):138-159. Characterizes phytoplankton communities in reference and degraded water quality conditions
- Phytoplankton Assemblages Associated with Water Quality and Salinity Regions in Chesapeake Bay, USA. Marshall et al. 2006. Estuarine, Coastal and Shelf Science 69:10-18. Further characterizes phytoplankton communities in reference and degraded water quality conditions
- Phytoplankton Index of Biotic Integrity for Chesapeake Bay and its Tidal Tributaries. Lacouture et al. 2006. Estuaries 29(4):598-616. Identifies discriminating metrics and establishes metric scoring protocols to calculate multi-metric PIBI
- Development and evaluation of a spatially-explicit index of Chesapeake Bay health. Williams et al. 2009. Marine Pollution Bulletin 59:14-25. Uses the Lacouture et al. scoring protocols and incorporates PIBI and chlorophyll a in a bay health index
- Revisiting the Chesapeake Bay Phytoplankton Index of Biotic Integrity. Johnson and Buchanan. 2013. Environmental Monitoring & Assessment DOI 10.1007/s10661-013-3465-z. Validates the PIBI with additional data and re-examines trends at Bay phytoplankton monitoring stations

[ 11 ]

## 2) Undesirable or nuisance aquatic plant life, food quality issues

- Excessive concentrations of undesirable taxa, e.g., bluegreen algae and some dinoflagellates
- Harmful algal blooms

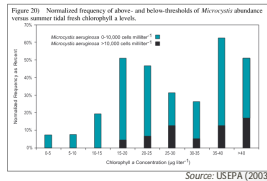
[ 12 ]

## Harmful Algal Blooms

- Original basis cited for 2005 James chl-a criteria:
  - USEPA (2003) criteria document, focusing on
    - M. aeruginosa*
    - P. minimum*
  - Some James (TF)-specific analysis of *M. aeruginosa* and vs. chlorophyll-a

### Limitations:

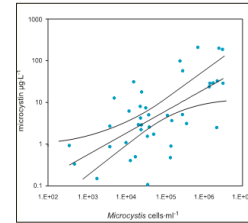
- Little information on toxins
- Little information on aquatic life impacts
- Incomplete information on controls



13

## Harmful Algal Blooms (cont.)

- New Data Available?
  - Yes
    - MDE Phytoplankton Monitoring Program
    - James River study
    - Others?
- New Evaluations Available?
  - Yes
    - USEPA 2007 addendum
    - Add others
    - Products of James River study
    - New James River model(s)

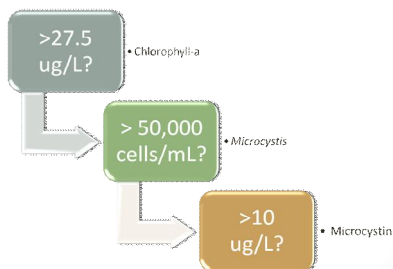


Potential Use for James: Direct Use for Criteria Development

14

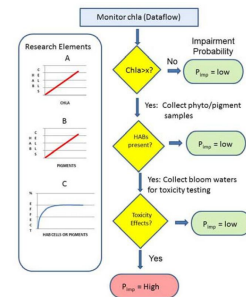
## From USEPA's 2007 Criteria

Addendum...concept of combined use of chl-a, taxa, & toxin data



15

## Similar concept in James River Work Plan



16

## 3) Natural characteristics

Trophic status of tidal James is currently undesirable

- "High to hypereutrophic" (NOAA 1997)
- "Eutrophic" (CBP 2003, VADEQ 2005)
- "Poor" Chla status (2004 Annual Report, VA Secretary of Natural Resources)

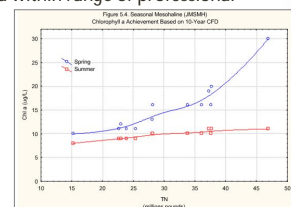
No new information /// supports James Chla criteria /// no further analysis



17

## 4) Attainment

- Original basis cited for 2005 James chl-a criteria:
  - Direct modeling of attainment
  - "James River Alternatives Analysis": DEQ (2005)
  - Used to adjust criteria within range of professional judgment
- Differences from TMDL approach:
  - Older model version
  - 10-year average vs. critical period



18

## Attainment (cont.)

- New evaluation?
  - Yes – new modeling James River modeling framework.
  - Alternatives analysis part of work plan.
  - May help address key questions:
    - How attainable are candidate chl-a criteria?
    - To what extent can HABs be controlled?
    - Are there points of diminishing returns?

**Potential Use for James: Similar use as in 2005, with updated modeling framework.**

[ 19 ]

## Relationships to DO and water clarity criteria

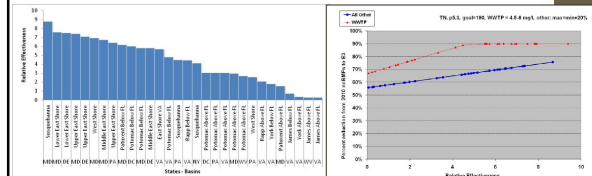
## Dissolved Oxygen

- Original basis cited in 2005 DEQ document:
  - Not intended as a direct basis of chlorophyll-*a* criteria
  - Document states intent to address “algal-related...impairments...likely to persist even after attainment of [DO] and water clarity criteria”
- Limitations
  - Redundant with other criteria
  - Uncertain, variable linkages to DO
  - Could lead to overcontrol

[ 21 ]

## Dissolved Oxygen (cont.)

- New evaluation available?
  - Empirical analysis for mainstem Bay; e.g. USEPA (2007)
  - DO-based TMDL allocations
  - New James River models will provide linkage



**Potential Use for James: Verification that that criteria would be protective of DO**

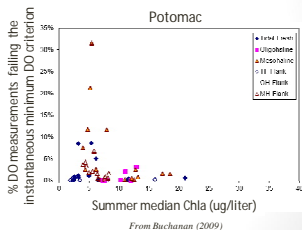
[ 22 ]

## Dissolved Oxygen

Analyses to test Dissolved Oxygen Umbrella Criteria concept (2009 – 2011)

In shallow waters:

- oxygen dynamics are not driven by excessive phytoplankton (Chl-a) in many locations
- only continuous monitoring buoy data accurately detects failures of the instantaneous minimum DO criteria



[ 23 ]

## Water Clarity

- Original basis cited for 2005 James chl-a criteria:
  - Not intended as a direct basis of chlorophyll-*a* criteria
  - Document states intent to address “algal-related...impairments...likely to persist even after attainment of [DO] and water clarity criteria”
- Limitations
  - Redundant with other criteria
  - Role of TSS, resuspension in James River

[ 24 ]

## Water Clarity

- Newer Data/Evaluation?
  - Approach of Harding and others (2013): Allocate a fixed fraction (30%) of the light attenuation to chl beyond that due to pure water alone to prevent dominance by chl<sup>a</sup>.

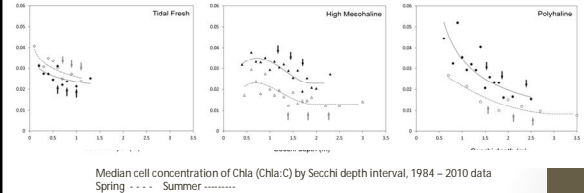
SAV Application Depth (m)	Chl- Target (ug/L)	
	TF/OH	MH/PH
0.5	62	44
1.0	28	19
2.0	12	8

**Potential Use for James:** Verification that that criteria would not prevent attainment of SAV/ water clarity acre goals

[ 25 ]

## Water Clarity

In general, water clarity may currently have a bigger impact on phytoplankton than phytoplankton (Chl<sup>a</sup>) have on water clarity.



Phytoplankton increase chlorophyll amounts in their cells when water clarity decreases (sediment, colloids, dissolved solids, organic particulates)  
... cells are thus capable of more rapid growth in nutrient rich surface layers

[ 26 ]

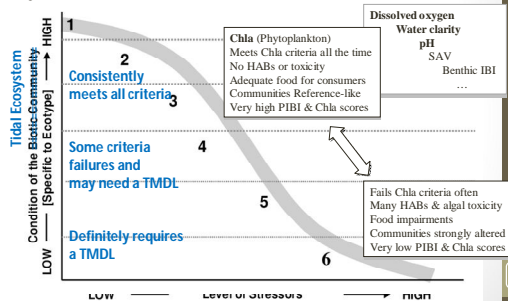
## Additional Suggestions

## Concluding Thoughts

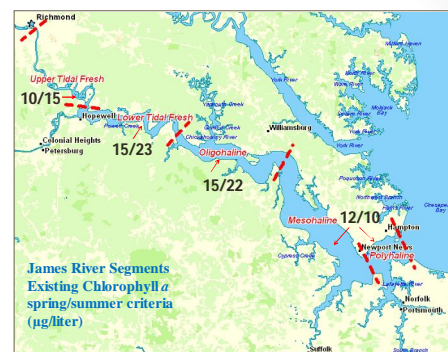
- HAB-based criteria may provide most direct link to beneficial uses
- Thresholds may or may not be might not be "bright line"
- Frequency/duration will strongly affect attainability
- Modeling team may be contracted to evaluate three sets of criteria
  - Existing
  - 2 alternatives
- Potential role for SAP: define the range of candidate criteria and ecological/use implications

## Characterize the levels of attainment

"Biological Condition Gradient" is a convenient framework



[ 29 ]



From Al Pollock's August 2011 presentation to James River Chl a Criteria SAP

[ 30 ]